William E. Rees, PhD—Overview of Research Interests and Contributions

In general, my research and related teaching focus on the policy and planning implications of global environmental trends and on specifying the ecological conditions necessary for sustainable socioeconomic development. Much of this work is in the realm of human ecology (where I am best known for originating 'ecological footprint analysis' [EFA]) and in ecological economics (I am a founding member and past-President of the Canadian Society for Ecological Economics [CANSEE]). The broadly trans-disciplinary nature of my work is reflected in the wide range of journals and books in which I publish and in the scope of scientific and policy conferences to which I am invited.

I have been motivated since the beginning of my career to develop models that reconnect humanity conceptually to the natural world in ways that reflect better reflect biophysical reality. I do this, by studying *Homo sapiens* in the same way that other ecologists might study non-human species, by attempting to identify and quantify in a readily understandable policy-relevant way, the material and energy flows that connect the human enterprise with the rest of nature. In short, my research is designed to contribute to the development of a more realistic human bio-ecological framework for future development. (Note that most traditional academic ecologists study non-human species only and some even regard humans as alien to ecosystems. This disciplinary perspective reflects the prevailing cultural dualism I refer to below.)

Clearly, one of my starting premises is that the prevailing industrial mindset for human development is unrealistic. Indeed, the industrial world is founded on a mechanistic 'scientific materialist' worldview that effectively treats 'the environment' and the human enterprise as separate systems. I believe that this dualistic world-view (a by-product of Cartesian dualism) is one of the root causes of humanity's prevailing unsustainable development path since it encourages the view that, through technology, the human system effectively floats free of any serious biophysical constraints. For example, many economists and technological optimists argue that the human enterprise is 'dematerializing,' that the economy is 'decoupling' from the ecosphere. Moreover, in recent decades, the notion that human ingenuity will find substitutes for any good or service now provided by the ecosphere has been elevated to near doctrinaire status. As the late Professor Julian Simon hyperbolically proclaimed, 'Technology exists now to produce in virtually inexhaustible quantities just about all the products made by nature…,' and '…to feed, clothe, and supply energy to an ever-growing population for the next seven billion years…'

By contrast, my and related studies of the actual physical relationships between humans and nature show that for all our technological sophistication, modern humans remain *integral dependent components* of all the significant kinds of ecosystems on Earth. Indeed, instead of distancing themselves from nature as mainstream economic thinking suggests, human beings have actually become the dominant consumer organism in every major productive land and aquatic ecosystem type on Earth. In terms of geographical range, population size, energy use, carbon dioxide emissions, and biomass consumption, the scale of the human ecological niche (and consequent impacts) exceeds that of other consumer species by orders of magnitude.

This is not merely a biological problematique—earth scientists assert that human activity has become the most significant geological force altering the face of the planet and climatologists agree that *H. sapiens* is now actually beginning to affect global climate. In short, far from

decreasing humanity's reliance on nature, the major ecological effect of technology has been to extend the scope and intensity of human exploitation of the ecosystems that support us.

Ecological Footprint Analysis (EFA) and Global Sustainability

My and my students' work, most significantly the development and application of ecological footprint analysis (EFA), has made a major contribution to the global sustainability debate. In particular, we have helped to reopen the question of human carrying capacity and have posed an irrefutable challenge to the argument that 'humanity is decoupling from nature'. The strength of EFA in catalyzing new thinking about sustainability is measured, in part, by the fact that my book on the subject (with my former PhD student, Mathis Wackernagel) is now available—by demand—in eight languages, including Chinese.

We define the ecological footprint of any specified population—individual, city, country, world—as *the area of productive land and aquatic ecosystems that the population requires to produce/process the resources that it consumes and to assimilate the wastes that it produces, wherever on earth the relevant land/water area may be located*. We show that with economic development and GDP (income) growth, individual and population eco-footprints inevitably expand, even in the world's most efficient economies—i.e., human demands and dependence on nature continue to increase.

EFA results further suggest that the aggregate human ecological footprint already exceeds the long-term biocapacity of Earth by at least 20% (a result supported by such empirically evident trends as accumulating greenhouse gases, fisheries collapses, land degradation, desertification, etc.). The average *per capita* human eco-footprint is approximately 2.2 hectares, compared to only 1.8 ha *per capita* of productive ecosystem on the planet.

Most alarming is the observation that the average eco-footprints of wealthy nations range from five to 10 ha *per capita*, 2.5 to five times the equitable or 'fair earth share' *per capita*. Nevertheless, the material standard of living represented by such large eco-footprints establishes a target that people in the developing world are struggling to attain. This target is, of course, unsustainable (unattainable) using anything like existing technologies. EFA shows that without a shift to as yet unknown alternative technologies, it would take four additional Earth-like planets to support just the present human population at North American material levels.

Such results have generated considerable controversy and, as noted, have contributed to re-kindling the debate on human carrying capacity and biophysical limits to growth. Most recently, (November 2005) the European Environmental Agency (EEA) released an eco-footprint analysis that effectively acknowledges global limits and the need for policy that acknowledges human carrying capacity. Particularly important is the EEA's recognition of the fundamental inequity implied by Europe's appropriation of almost three times its fair share of the earths biophysical output. With just 7 % of the world's people, Europe uses about 20% of global biocapacity. (The EEA's study follows from the European Parliament's release of the European Eco-footprint report in June.)

Because it poses a fundamental challenge to prevailing global development models, unfettered trade and continuous economic growth, EFA has been the focus of numerous international workshops, conferences, explicit debating forums in prominent journals such as *Ecological Economics* and entire books. The concept has been featured/debated in both *Nature* and *The*

Economist, and there is common reference to the human 'ecological footprint' in world newspaper accounts of global change. The human 'ecological footprint' is now frequently referenced in speeches by prominent political leaders and UN officials, and results of EFAs are cited in reports by major international non-government organizations. (For example, EFA has been adopted by the WorldWide Fund for Nature [WWF] as a co-indicator of sustainability along with the WWF's own Living Planet Index.)

As a result of this flourishing debate, 'ecological footprint' is now an entry in the Oxford dictionary of the English language—indeed, the phrase has become part of the contemporary vernacular. (Appendix 1 describes some of the features of EFA that account for its effectiveness as an heuristic device and communications tool.)

Time magazine (Canadian edition) recognized me and the power of the ecological footprint concept in a feature story, "Taking Measure," in the 'Science' section of the 10 October 2005 edition.

Appendix 1

Strengths of EFA

The success of EFA derives in part from methodological strengths of the method that are both scientifically well-founded and that reflect thinking people's intuitive sense of reality. On the technical/scientific side, EFA has several qualities that reinforce its credibility as a sustainability indicator. The method:

- acknowledges that humans are biophysical entities that make constant metabolic demands on their supportive ecosystems and that all our manufactured capital and related cultural artefacts impose a parallel and much larger industrial metabolism on the ecosphere;
- recognizes the crucial role of natural capital and natural income (biophysical stocks and flows) in economic development and sustainability;
- accepts that the economy is a fully contained, growing, dependent, sub-system of the non-growing ecosphere;
- recognizes the second law of thermodynamics as the ultimate governor of material transformations and economic activity and that beyond a certain (optimal) scale, the growth and maintenance human enterprise must necessarily accelerate the entropic disordering and dissipation of the ecosphere;
- is closely related conceptually to Howard Odum's the embodied energy (emergy) analyses and the 'environmental space' concept of European sustainability analysts.
- corresponds closely to and incorporates all the factors in Ehrlich's and Holdren's well-known definition of human impact on the environment: I = PAT, where 'I' is impact, 'P' is population, 'A' is affluence (i.e., level of consumption) and 'T' is a technology scalar.

One result of the wide compass of EFA is that critiques, modifications and applications of the method now fill hundreds of pages in the academic literature each year.

EFA has also gained great popular acceptance. It seems to resonate better with the public than do more abstract and impersonal sustainability indicators. Attributes of EFA that help to communicate biophysical reality to the public are as follows:

- The method is conceptually simple and intuitively appealing. *Even sceptics recognize that that they have a positive ecological footprint.*
- EFA personalizes sustainability by focusing on consumption—everyone is a consumer and must ultimately take responsibility for his/her own 'load' on the planet.
- EFA consolidates measurable energy and material flows into a single concrete variable, the corresponding appropriated land/water (ecosystem) area.
- Productive land/water area itself is a powerful indicator that anyone can understand.
- Eco-footprint estimates can be compared to finite local and global 'supplies' of terrestrial and aquatic ecosystems (i.e., people and populations can compare their demands to available bio-capacity).
- The 'ecological deficit'—the difference between domestic bio-capacity and a larger eco-footprint—requires little explanation and many people see it as more important than the fiscal deficits with which their governments are often preoccupied!

Most important, EFA seems to serve as an important consciousness-raising tool as illustrated by the popularity of EFA-oriented web-sites that offer simple calculators that visitors can use to estimate their personal eco-footprints. To reiterate, EFA forces people to reflect on, and take responsibility for, their personal consumption habits. (One indicator of the concept's impact is the 1,160,000 web-page references obtained by 'Googling' "Ecological Footprint.")

Applying EFA in Sustainability Assessment

Governments, public agencies and private corporations are increasingly using EFA in their sustainability planning. Close to home, in 2005 British Columbia Hydro completed a corporate eco-footprint study and is planning to use the results to monitor its intent to increase energy production while reducing its ecological impacts. (I was part of the Scientific Panel for this study.)

EFA can be to compare the relative sustainability of competing production technologies. In BC, we have applied the method to show the hidden ecological costs of net-pen salmon farming compared to traditional fleet fishing and the much greater ecological impacts of greenhouse tomato production compared even to high-input field production. In the same vein, two of my graduate students have just completed a comparative analysis of pulp (for paper) production comparing the eco-footprints generated by wood-based mills with those using agricultural residues in the Canadian Prairie provinces.

Dozens of cities, state and even national and supra-national governments around the world are using EFA to calibrate and monitor their sustainability initiatives. Most significantly, in June 2005, the European Parliament released its *Europe 2005: The Ecological Footprint* report. This study shows that with only 7% of the world's population, Europe generates 17% of humanity's global eco-footprint (20% of global biocapacity). Europe's eco-footprint is 2.2 times larger than its domestic biocapacity—the Euro-Community is running an enormous unsustainable ecological deficit with the rest of the world.

From the evidence, EFA has arguably had at least as great an impact on the international sustainability debate as any other sustainability indicator.